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MARATHON TO THE STARS:
HOW THE US CAN AVOID LOSING THE GLOBAL SPACE RACE

by

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PREFACE

Air Force Acquisition is not broken. Neither is the process in the Army, Navy, or the Marine Corps. The same holds true for space acquisitions. From my experience, archaic regulations, a leadership cadre borne from the remnants of the Cold War, and an overarching 'Not Invented Here' mentality conflict daily with the younger minds immersed in the ubiquitous realm of information and questioning of the status quo. It will be when the experience of those that came before melds with the energy of those to come when we finally achieve our potential.

The US government has accomplished an amazing feat by bringing the rest of the world's space faring nations to the precipice of an industrial revolution beyond the earth. The information age has created an interconnected, global economy dependent on the very space systems once meant to keep it apart. It is time for the mantle to pass and for governments to reap the benefits of what they have sown. There is no knowing where we may end up when government and industry, the old and the new, work together.

I would like to thank my wife, Sarah, and my daughters, Clara and Eve, for their understanding over the past two years of this program. I would also like to extend my thanks to my instructors who valued the opinion of those who step beyond the accepted norm, and intelligently, consistently ask the simple question, "Why Not?"

ABSTRACT

The United States' ever growing reliance on space assets requires a paradigm shift in how the government invests resources to obtain high quality capabilities, and remain ahead of international peers in the global space race. This research paper answers the question, what specific technology investment strategies should the US take to increase its position among the international space powers? Using a problem-solution methodology, an optimum investment strategy is determined and then compared against the current investment approach of the US. The US currently relies heavily on direct government-led funding and development, leveraging very little of the vast commercial potential within the US and international community resulting in high costs, long schedules, and a lack of innovation. This conclusion supports the recommendation that the US must greatly increase the use of commercial assets for space launch, satellite communications, and imagery intelligence, and pursue international cooperation for space exploration.

INTRODUCTION

To fulfill the United States' (US) National Space Strategy and avoid falling behind other global space powers, specific shifts in US technology investment must be implemented. Due to an ever growing reliance on and cost of the space medium for communication, navigation, launch, intelligence, and exploration, the US must leverage a combination of government-industry partnerships, commercial ventures, and international cooperative development to compete against international rivals and maintain an edge in the space arena. Although the United States sprinted ahead of the world at the beginning of the Cold War space race, and continues to spend large amounts of money for space assets, the rapid advancement of technology has allowed new competitors to catch and even surpass the US in key areas.[1]

A multi-faceted approach to space development can provide "[t]he sharing of risk and cost, coupled with technological crossflow…"[2] that cannot effectively be achieved by government investment alone. A failure to efficiently and prudently invest for future development could present an insurmountable obstacle should the US begin to lag behind other space powers.[3] This research paper answers the question, what specific technology investment approaches should the US take to increase its position among the international space powers?

Significance

At the end of the Cold War, with the fall of the Soviet Union, the US became the front runner in the space race. The US continued to dominate the space realm through the development of a robust space launch capability, an extensive space based situational awareness and missile warning capability, and the world's premier constellation of navigation, communication, and intelligence, surveillance and reconnaissance (ISR) spacecraft.[4]

The past twenty years, however, have showcased a dramatic shift in the international space arena. A resurgent Russia, a conglomerated European Space Agency, and a newly minted Chinese National Space Administration have leveled the playing field, and in some areas even surpassed US capabilities. This has been done by capitalizing on inherent strengths, leveraging existing technology, and exploiting weaknesses in the current investment structure of US assets.

At the same time within the US, "Warfighting Commanders-in-Chief (CINCs) now routinely plan exercises and employ forces under the assumption that they will have unimpeded access to Global Positioning System (GPS) and communication satellites as well as meteorological and Intelligence, Surveillance and Reconnaissance (ISR) platforms."[5] Additionally, the US civilian populace has grown accustomed to the unfettered availability of satellite-provided entertainment and conveniences. Any disruption to these services could catastrophically affect the nation's security, and greatly impact the space technologies upon which US citizens rely.

The US faces a number of hurdles in the ability to compete against new rivals. An anticipated replacement cost of $60 billion for each currently fielded system is unpalatable to a country facing enormous budget deficits and a declining space budget.[6] Also, bureaucratic red tape has stifled innovation and instilled a risk adverse mentality that has thwarted the ability to exploit emerging technologies. Finally, public sentiment has turned against the space program, thought to provide little benefit compared to the high taxpayer cost.

Purpose of the Study

The US needs to implement specific steps that leverages the private sector in the refinement and operation of developed technologies, and works cooperatively alongside international partners to enhance long term research and cost sharing. This research paper recommends those specific steps and areas of investment required to implement the US National Space Strategy, "in order to increase knowledge, discovery, economic prosperity, and to enhance the national security…"[7] The areas of investment under consideration are assured access to space, satellite communications, imagery intelligence, space exploration, and satellite navigation.

BACKGROUND

The current space race is the culmination of many decades of development, competition, success, and failure. Starting during the Cold War, the relative capabilities of each country have waxed and waned over the years affecting the overall standing of world leaders. The history of the space race provides a glimpse into the current policies of each nation, and provides context for the actions of the future.

Short History of the Global Space Race

The Cold War

The Space Race officially began with the Soviet launch of the Sputnik I Earth orbiter on October 4, 1957.[8] The US responded shortly thereafter with the Explorer 1 spacecraft on February 1, 1958, carrying a scientific payload designed by James Van Allen which eventually discovered Earth's radiation belts.[9] These innocuous beginnings would spawn several notable firsts over the next twenty years.

The Union of Soviet Socialist Republics' (USSR) space program pioneered space exploration through the 1960's and 70's. While not always successful, the Soviets operated the first manned space flight (1961), built the first maneuverable spacecraft (1963), conducted the first 'space-walk' (1965), performed the first soft landing on the Moon and Venus (1966 and 1967), and designed the first orbiting space laboratory (1971).[10] Although never able to land a human on the moon, the USSR did continue to fly the Luna Orbiter through the 1970's, as well as a series of Venus orbiters and landers.[11]

US efforts during the Cold War were characterized by a series of planetary exploration spacecraft, and the more widely recognized human spaceflight missions of Mercury, Gemini, and Apollo. The Mercury missions (1958-1963) began as an effort to place humans in orbit, and investigate the ability to operate within the space environment.[12] Mercury evolved into Gemini (1962-1966), designed to test new equipment, train astronauts and ground crews, and conduct extravehicular operations, which supported the Apollo program (1963-1972), culminating in the Apollo 11 moon landing in the Sea of Tranquility on July 20, 1968. [13,14] The US would continue to explore space through the 1970's with the Viking and Voyager missions, SkyLab, and the development of the reusable Space Shuttle.

End of an Era and US Dominance

The Soviet Union began to crumble toward the end of the 1980's marking the end of the initial leg of the global space race. Although Russia continued to conduct space missions, the ambition was markedly lower. The MIR space station would continue to operate through the 90's, but the US operated Space Shuttle became the more prolific space platform, ushering in the 1990's with the US as the dominant space power.

As the millennium drew to a close, the US remained as the sole "superpower." Armed with the reusable Space Shuttle, the US embarked on a series of expeditions to push the boundaries of technology and human knowledge. Starting with the launch of the Edwin P. Hubble Space Telescope on April 24, 1990, the US would lead the world in space exploration for the next 15 years.[15] Additionally, as GPS, satellite communications, and space based ISR platforms became more prevalent, military commanders would truly begin to realize the benefits of space in the conduct of war, and civilians grew accustomed to the capabilities space based assets could provide.

Rise of Europe

The European Space Agency (ESA) formed in 1973 to “provide for and to promote for exclusively peaceful purposes, cooperation among European States in space research and technology and their applications, with a view to their being used for scientific purposes and operational space application systems.”[16] Now representing 15 countries, the ESA is considered one of the leading world space agencies.[17] Although each member is required to support ESA activities, nations still retain some autonomy to seek country specific space endeavors. Europe has seen great success for the past 30 years with the development of the Ariane series of boosters, numerous science experiments to the sun, Saturn, Venus, and Mercury, meteorological spacecraft, telecommunication satellites, and support to the International Space Station.[18]

China Joins the Pack

Although China’s first satellite was launched on April 24, 1970, the more recent accomplishments over the past 10 years have drawn China even with the other major powers.[19] In 1999, China first launched and recovered an unmanned spacecraft designed as an initial foray into manned spaceflight.[20] In 2007, China launched the country’s first lunar orbiter, performed a spacewalk in 2008, and plans to have a manned space station and lunar landing by 2020.[21]

A key distinction between the legacy space powers and China is the level of national pride and public support for each country’s space program. While public support for space has waned significantly in the US since the 1980’s, China “views the development of space and counterspace capabilities as bolstering national prestige…demonstrating the attributes of a world power.[22] This could potentially reduce US influence among developing nations when competing against China to become the primary supplier of space assets to emerging economies in South America and the Middle East.[23]

Present Capabilities of the World Leaders

The Soviet Union led the initial phase of the Space Race for the first 15 years, with the US close behind. As the US witnessed Russia falter, new challengers emerged in Europe and China, leveraging the developed technology of opponents at a fraction of the cost, and narrowing the advantage of the world leader. Currently, each country draws upon comparable technology (Table 1) with only slight advantages over one another.

	United States[24]	**ESA**[25]	**Russia**[26]	**China**[27]
Space Launch	- EELV (Atlas V and Delta IV)	- Arianne 5 - Vega - Soyuz	- Proton - Soyuz	- Long March (10 configurations) - Mobile Launch Vehicle
Communication	- WGS - Milstar - TDRSS	- Alphabus - Hylas - European Data Relay Satellites	- Meridian - Raduga-1	- Chinasat - Apstar - Asiasat - Sinosat
Reconnaissance	- Robust Military Support	- Envisat	- Almaz - Araks	- Ziyuan - JianBing 5
Space Exploration	- Space Shuttle (to be retired in 2010) - International Space Station	- Automated Transfer Vehicle - International Space Station	- Progress - International Space Station	- Recent venture with planned lunar landing in 2020
Navigation	- GPS 2	- Galileo	- GLONASS	- Beidou

Table 1. Current space capabilities by country

Today's Space Race showcases a field of four near-peer competitors, each with specific strengths, weaknesses, and strategies to significantly shape the future. Even with the US drastically outspending Russia, China, and Europe (Figure 1) the competition is not far behind.

The Space Race will no longer be decided solely on the basis of sheer expenditures, but on the method in which these investments are made in order to gain the most benefit.

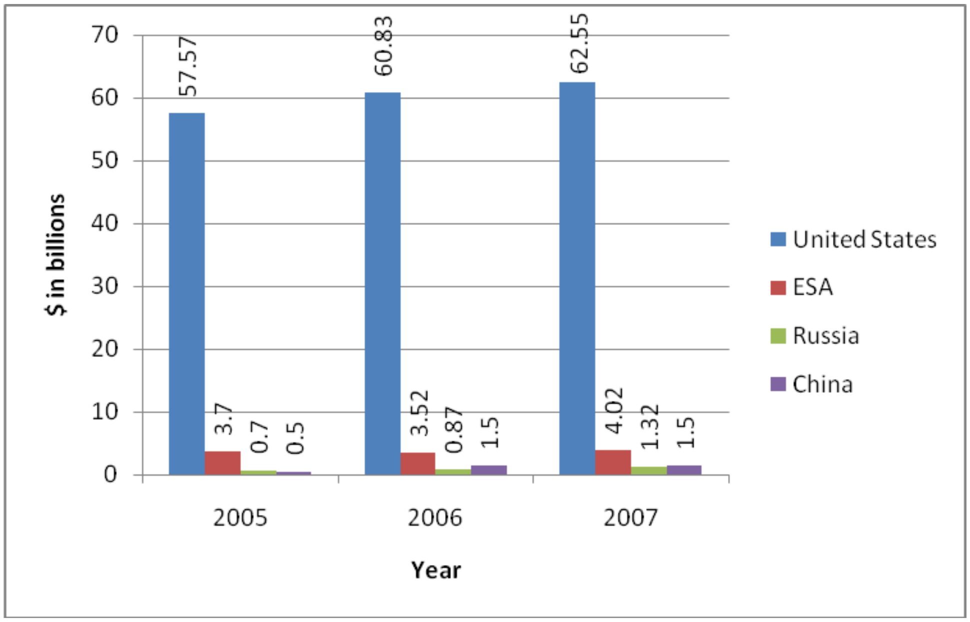

Figure 1. Government space budgets 2005-2007 (Adapted from "Global Space Activity Revenues and Budgets," The Space Report 2009, Space Foundation, 2009.)

EVALUATION

Methodology

This research paper uses the Problem/Solution framework to establish the most beneficial investment strategy for each space capability, and to analyze and provide recommendations to US space policy. The primary criteria to select the most optimum strategy are the abundance or lack of commercial options compared against the level of dual-use of the technology. Dual-use is defined as being applicable to both the civil and government sectors. A secondary consideration is the inherent advantages and disadvantages for each strategy. The secondary criteria consist of the relative cost savings to the government, the schedule impacts to implement and meet requirements, the ease of implementing each strategy, the social benefits that can be gained from the use of a specific strategy, the amount of requirement tailoring that can be conducted, and finally the level of innovation leveraged. The investment strategies for consideration are Government Funded, Government/Industry Partnerships, Commercial Ventures, and International Cooperation.

A review of the advantages and disadvantages for each strategy, coupled with the applicability of the strategy to each space capability provides a template to compare the current US strategies employed against the optimum approach. This comparison also identifies weaknesses in US space policy, and provides the support for recommended changes.

Investment Strategy Options

In order to determine the optimum investment strategy for each space capability, a general understanding of each is required. The investment strategies include Government Funded, Government/Industry Partnerships, Commercial Ventures, and International Cooperation. This section defines the characteristics of each strategy, and identifies the advantages and disadvantages for each option.

Government Funded

The Government Funded investment strategy typifies the prototypical acquisition of technologies through large defense contractors managed by government officials. This procurement process encompasses the entire lifecycle of the product to include conception, requirement generation, design, low rate initial production, operations, maintenance, and disposal. More importantly, each of these phases is directed by the government, and conducted at government expense.

The largest benefit of this approach is that anything designed is tailored directly to government requirements regardless of the viability of a commercial market for the end product. The government, acting unilaterally, can uncover solutions that neither the commercial sector, nor international partners, may be willing to risk finding, generating results that align with US national interests.[28] This is also the easiest strategy to implement since methods of placing the defense industry on contract tend to be readily available and understood. Additionally, most defense contractors are familiar with, and have the appropriate certifications required by federal regulations, and are generally well versed in working with government bureaucracy. Ancillary support for direct government funding stems from potential social gains. Unlike the private sector, which is primarily focused on the short term profitability of new products, the government is able to act in the best interests of the country in general, overcoming failures of the free market system to take into account social causes.[29]

From a negative perspective, although government funding may be used to achieve a sense of social justice, history demonstrates that this is usually not the case. "All governments selectively support some of their constituents on grounds of ideology, special need, demonstrated sympathy, political power, or electoral contribution."[30] Thus, the federal government can be rated as poor in allocating resources effectively. Government officials, beholden to constituencies and subjected to political pressures, spend tax dollars less on satisfying customers, and more on appeasing voters.[31] Additionally, the current federal acquisition process is slow, cumbersome, and expensive. Ongoing space development within the US costs $5-10 billion per system, excluding the $11,000 per pound launch costs.[32] Since this is fully financed through government spending, there is no availability for cost sharing. The lengthy time required to build space systems through this process results in equipment that quickly becomes obsolete, and is easily exploited by adversaries that can operate inside the US development cycle.[33] Finally, the use of large defense contractors can stifle innovation. "'When a big aerospace company comes in and takes over one of these startups before frontiers have been opened'…there's a risk that 'the old-school mentality will suffocate [the new industry] even before it gets born'."[34] This is further exacerbated by the fact that the number of top aerospace firms in the US declined markedly during the first five years of the 21st century dropping from 107 to only five by 2004.[35]

This strategy is most applicable when the number of commercial options is very small, and the significance of the technology is limited to national security interests rather than the commercial market (see Figure 2). Any development can be focused explicitly on the needs of the government, while simultaneously minimizing exposure to foreign adversaries or commercial competitors. However, innovation is likely negligible, the direct cost to the government is typically higher than other strategies, and the schedule longer than commercial solutions.

Government/Industry Partnership

The Government/Industry Partnership strategy leverages the benefits of the private sector to meet specific government needs. The Government provides the initial concept and dictates the end result, but any design trade-offs are conducted by industry. The end product is then owned by the company and sold back for government use as either a commercial product or service.[36] The partnership can be formed between the government and any external company, either a purely commercial entity or part of the military industrial complex.

This partnership helps to overcome the technology hurdle of the private market. "Private industry alone cannot handle large technological challenges for a simple reason; private industry has to focus on the short term."[37] The commercial sector is usually unwilling to spend enormous sums of money developing a new product that may not have a viable market that will then be available to competitors at a much lower cost.[38] Additionally, generating the initial capital to support a 10-20 year time horizon is nearly impossible.[39] Instead, the government funds the non-recurring costs to develop the new capability, and allows industry to make the innovative changes necessary for upgrades. This strategy can also be used to upgrade existing systems without the need to redesign from the beginning. The intent is to insert commercial products into a military system to "reduce parts obsolescence as well as space parts and software maintenance costs…reduce unnecessary replacements, testing time, and effort.[40]

A disadvantage of this strategy is the close ties between the company developing the product, and the product itself. Since this is not a true commercial acquisition, wherein the government purchases an already developed product, the likelihood of facing proprietary issues is much higher. This could potentially limit the ability to upgrade future systems with third-party solutions. Also, public support for government expenditures to mature commercial technology is very low, making the political viability of this strategy difficult.[41]

A second disadvantage is the potential conflict of interest between the private and government sectors during times of crises. If the end product is provided to the government on a service basis, or with limited availability, the government and commercial provider must make arrangements to ensure the capability is provided when needed. Anticipating expected needs during periods of relative stability is easy, but during national emergencies or ambiguous military operations, fluctuating accessibility requirements may make this strategy untenable.[42]

A final disadvantage is the possible continuing need for a government supported market. A product specifically developed to meet government requirements may not transition well to the commercial sector. Much like the current launch vehicle industry, a successful partnership may require "government support and backlog to maintain a healthy and economically viable production yielding reliability [and] quality."[43]

This strategy is most applicable to the development of technology that has a widespread commercial understanding, but requires meeting specific requirements (see Figure 2). The final product may or may not have a viable customer base, so the need for continuing government support could remain. However, the ability to leverage commercial innovation to lower costs and shorten schedules is beneficial.

Commercial Ventures

Commercial Ventures represent the antithesis to the prototypical government acquisition. Under this approach, companies design, build, test, and sell products that generate the largest revenue within the commercial marketplace, leverage internal engineering processes, and view the government as just one of many potential customers.

The primary impetus for this strategy is the belief that "the free market system is the only known way that, on a large scale, resources can be used in the most efficient manner to satisfy the needs of individuals."[44] Those companies which are most efficient at producing the best product will thrive, while those who cannot will be removed from the marketplace.[45] The focus, therefore, is on the end product and profit potential, not on a company's ability to exist within the government bureaucracy. To maximize profits, commercial companies need constant innovation to increase production, reduce overall lifecycle costs, and provide state-of-the-art products to appeal to a wide range of customers.[46] A second benefit is the relative freedom of the commercial sector to flexibly respond to requirements. Since private companies are not as tightly bound by federal standards and regulations while dealing with other companies, industry can purchase, develop, or modify available systems or components to fulfill the mission.[47]

The primary disadvantage of commercial ventures is the need for a commercial market. Space systems are expensive, risky, challenging, and require a steady return on investment to maintain the funding and workforce necessary to build complex spacecraft.[48] If the risk becomes too high, companies will be unwilling to invest in the development of the system, eliminating the possibility of using this strategy. The space industry has firsthand experience with this situation.

In 1998, the global economy was expected to one day provide over $500 billion and up to 1,500 satellite launches, but that level of activity never materialized.[49]

A second disadvantage exists if the government purchases a commercial service to meet requirements. Since the government is only one among many customers, the possibility for resource contention can arise. Much like the Government/Industry Partnership, agreements need to be in place to address fluctuations to meet surge requirements in case of national emergencies. Also, commercial products are developed to meet a commercial need, and will most likely not meet every government requirement.

This strategy is most applicable when a large number of commercial providers of dual-use technologies exist (see Figure 2). A large pool of suppliers presents a variety of options to most effectively meet national requirements, while spurring competition for better, cheaper products. A large consumer base alleviates the need for continued government support. This strategy requires the government to be more open to methods of meeting requirements, and may not be available for all capabilities depending on market conditions.

International Cooperation

The International Cooperation strategy leverages the knowledge, cost sharing, and global participation in the space environment. Development consists of any combination of government and commercial involvement, from any number of countries, either through monetary contributions, technological enhancements, or personnel support.

The strongest rationale for international cooperation stems from the multilateral approach. This strategy "provides benefits across the international spectrum, including trade, investment, intelligence sharing, and space operation…by building an atmosphere of trust and a greater willingness to engage in dialogue and to cooperate on matters of mutual national interest."[50] These benefits manifest in cost sharing, increased political and public support, and the social benefits generated from worldwide participation. A secondary advantage of international cooperation is the increased transparency of foreign developments. For countries to work together, a certain level of dependency on one another's technology is required, providing insight into adversaries' capabilities, and the ability to influence each other's progress.[51]

The primary weakness is the sustained involvement of international partners, for which no effective model currently exists. The development of the International Space Station left many participants wary of subjugating national funding and pride to US management.[52] Similarly within the ESA, favoritism and perceived fairness drive decisions rather than efficiency and accomplishment.[53] As such, international cooperation is the most difficult strategy to implement. The need for extensive negotiations can drastically increase the length of time required to develop a capability, and the overhead cost associated with multiple partners can be staggering. The International Space Station is a prime example with a price tag exceeding $100 billion, and a timeline lasting over ten years.[54]

A second weakness is the potential for technology transfer to other countries. Cooperative development inherently requires a general understanding of how all activities work together to form a whole. This strategy also supplies countries access to US assets without the need to pay. For instance, the GPS constellation was developed and funded entirely by the US, but the global reach of the capability is provided to the rest of the world for free.[55]

This strategy is most applicable to the development of dual-use space systems, with few indigenous commercial options, and that do not pose a national security threat (see Figure 2). The cooperative nature permits cost sharing, and increased social and political benefits, but at the cost of lengthy schedules, a difficult implementation, and a limited ability to tailor national security specific requirements.

__Summary of Investment Strategy Options__

The primary criteria delineating each strategy is the number of commercial options compared against the level of dual-use of each technology area as summarized in Figure 2.

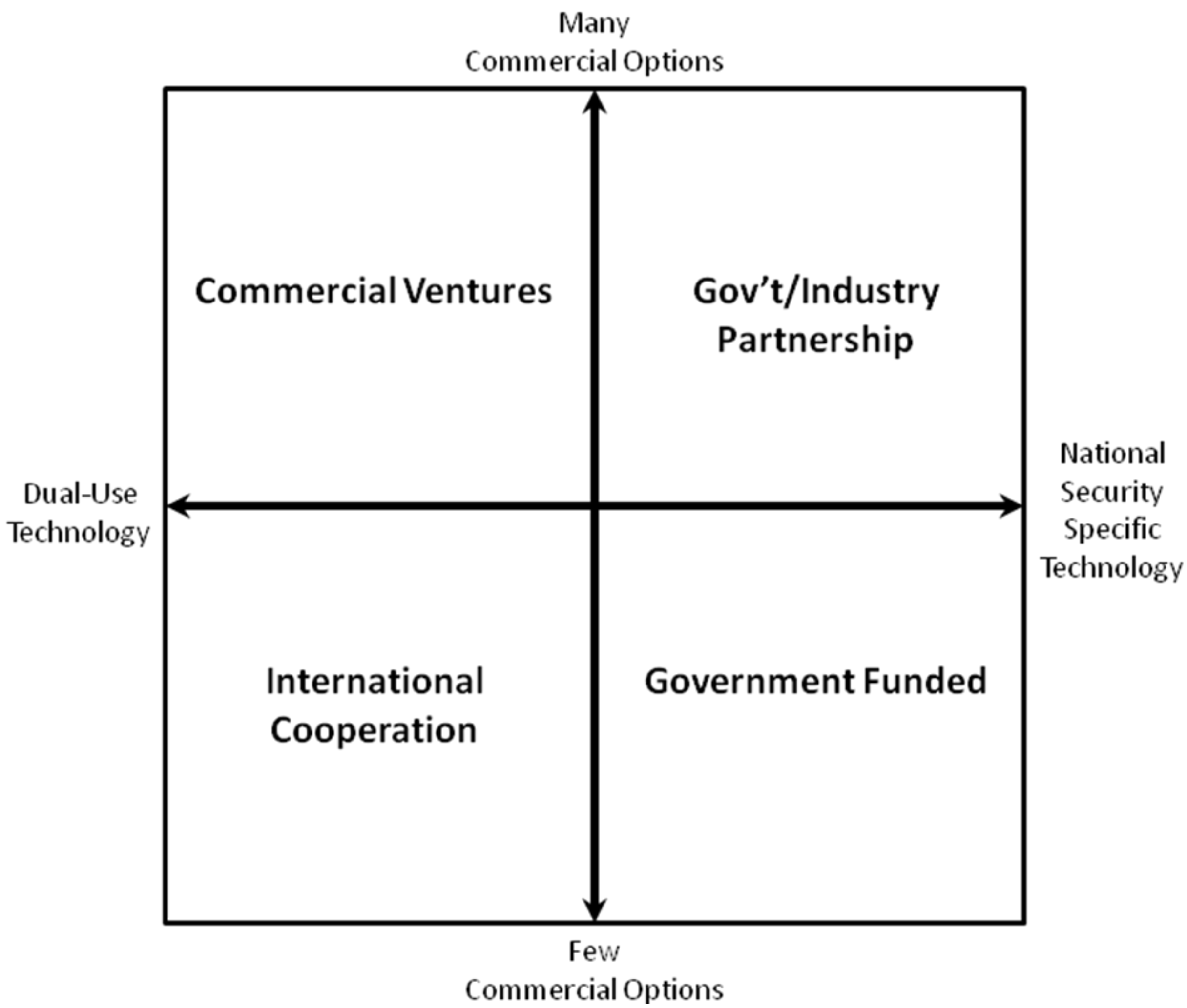

Figure 2. Summary of investment strategy options

Each strategy's attributes further refine the most optimum choice of investment strategy based on relative cost, schedule, ease of implementation, potential social benefits, the ability to tailor requirements, and the level of innovation available. Table 2 provides a comparison of these advantages and disadvantages.

		Attributes					
		Cost to Gov't	Schedule	Ease to Implement	Social Benefits	Req't Tailoring	Level of Innovation
Strategy	Gov't Funded	Highest	Long	Easiest	Some	Highest	Lowest
	Gov't/Industry Part.	High	Short	Easy	Some	Many	Some
	Commercial Ventures	Lowest	Shortest	Difficult	Fewest	Lowest	Highest
	Int'l Cooperation	Low	Longest	Most Difficult	Most	Some	Some

Table 2. Summary of investment option attributes

ANALYSIS

Space Capabilities for Evaluation – Optimum Strategy

The combination of primary and secondary criteria dictates the most optimum strategy for each individual space capability. The capabilities under consideration are assured access to space, communications, imagery intelligence, space exploration, and navigation. The optimum strategy is then contrasted against current US investment policy to identify disconnects, and provide support for the recommendations to space policy.

Assured Access to Space (Space Launch)

Assured access to space continues to be of high interest to national security, but recent demand within the commercial market has dramatically shifted the availability and quality of launch services. Government launches continue to make up a portion of launch provider manifests, but government is no longer the primary customer. "Today, more launches are dedicated to commercial purposes than to military ones."[56]

The commercial market has taken advantage of innovate designs, and the availability of foreign technology to provide reliable, non-governmental solutions to access space. Within the United States, International Launch Services (ILS) flies Russian Proton boosters from various locations throughout the world, and recently placed a Sirius/XM communications satellite into geostationary orbit.[57] A competing firm, Space Explorations Technology Inc. (SpaceX), is developing the Falcon-1 and Falcon-9 with the revolutionary goal of cutting launch costs to ten percent of current prices.[58] United Launch Alliance's (ULA) Atlas V and Delta IV continue to perform admirably, with the Atlas class of vehicles reaching 86 consecutive, successful launches.[59] Finally, SeaLaunch, still mired in bankruptcy, but attempting to recover, offers the novel approach of launching small payloads from anywhere in the world aboard a floating pad. While recent attempts to cut launch costs have been unproductive, the current environment demonstrates a viable commercial market willing to innovate to meet customer needs.[60] There is little social benefit to be gained directly from this capability, and requirements are comparable between the civil and government sectors.

The optimum strategy for assured access to space is Commercial Ventures due to the combination of increasing dual-use of launch services, and the large pool of potential commercial options (see Figure 3). Although additional options exist in the international community, the benefits provided do not outweigh the associated disadvantages, nor overcome the advantages of the commercial market.

Communications

Of all space capabilities, "the satellite communications industry is the most mature of all space industries, with most of the present and almost all of the emerging space communications systems owned, built and launched by multinational consortia."[61] The past 20 years of development have wrought an immense network of satellites with redundant capability available to both military and commercial buyers.[62]

The commercial market has driven communication availability to near over-capacity to meet ever growing demand.[63] To increase market share among this demand, companies have increased the capability of communication satellites to reach more customers and provide a better product, while reducing the cost of launching the satellite through techniques to reduce the overall weight. The innovative hallmark of the commercial sector allows industry to fabricate more advanced, cheaper solutions much more quickly than the government.

Within the commercial market there are multiple methods to meet existing requirements. As in the past, the government can contract directly with a satellite developer to engineer a specific communication system. A second option is to purchase commercial-off-the-shelf (COTS) assets to avoid the cost and schedule impacts of a new development. A third possibility is to lease communication time from available providers. More specifically, governments can use the services of a centralized purchasing agent to balance demand over a range of available assets. Current ESA attempts to implement this approach are estimated to have a cost savings of 30-50 percent, and provide a more stable, long term solution.[64]

Given the level of innovation, the sheer number of available assets, and the high level of dual-use for communication capabilities, the most effective strategy to meet national requirements is to leverage the commercial industry (see Figure 3). There may be some disconnect concerning military unique requirements, but the significant cost and schedule savings associated with the commercial market more than compensate.

Imagery Intelligence

Until recently, access to the imagery intelligence (IMINT) domain was primarily a characteristic of “superpower" governments. However, IMINT capabilities now represent an easy entry point for countries entering the satellite business due to the low cost and ease of manufacturing.[65] While military and government agencies will continue to require specialized capabilities, new commercial technology is available that meets a wide variety of requirements.

Within the United States, a number of commercial providers offer solutions that meet military needs. In the visible spectrum, DigitalGlobe's October 2009 launch of the WorldView-2 satellite offers sub-meter resolution and doubles the company's collection capacity to over 500 million square miles per year.[66] Also, numerous international firms have commercial space radar options available including MDA of Canada, e-Geos in Italy, TerraSAR-X in Germany, and TecSAR, built by the Israeli Ministry of Defense.[67]

A number of options exist to obtain IMINT capabilities. In addition to developing a solution, governments can purchase already developed satellites, or buy imagery products as a service from commercial industry; all of which meet a wide array of existing requirements, have ready-made software packages, and commercially available ground segments.[68] More importantly, the commercial options can be purchased cheaper and more quickly than developing a military specific application.[69]

The optimum strategy for IMINT capabilities is Government/Industry Partnerships (see Figure 3). Even though commercial assets can supplement government satellites, commercial solutions alone cannot fulfill the need for specific, on-demand, high resolution images.[70] This option allows a limited amount of requirement tailoring, and leverages some commercial innovation, while taking advantage of the abundance of current solutions.

Space Exploration

A few developments in recent years indicate a small, yet growing, international capability for manned space exploration. The continuing operation of the International Space Station (ISS) requires supply vessels to re-populate and re-supply the orbiting platform. Additionally, the moon and Mars continue to occupy scientists' minds for eventual manned space exploration, spurring the development of systems capable of carrying human life beyond earth's surface.

Even though the US plans to retire the Space Shuttle in 2010, Russia continues to operate the manned Soyuz capsule, and the Chinese Shenzhou spacecraft offers another viable alternative.[71] Commercially, SpaceX is developing the Dragon capsule, capable of carrying seven passengers to the ISS via the Falcon-9 booster.[72] Innovative propulsion, electronics, and ground operations have streamlined the system to reduce planned costs to $20 million per launch, 10 percent of the cost to launch an Atlas V.[73] Space systems to re-supply the ISS are also in development. The ESA recently fielded the Automated Transfer Vehicle (ATV) as part of the arrangement with NASA in lieu of payment for ISS operating expenses. The ATV provides over three times the cargo capacity of the Russian Progress vehicle.[74]

Numerous discussions for missions beyond low earth orbit are also underway; China and Russia have discussed cooperating on joint Mars exploration and lunar programs.[75] Similarly, the ESA is conducting initial studies with Russia regarding the development of a crew transport vehicle.[76] However, as with many multi-national efforts, current negotiations between Europe and Russia have slowed due to issues regarding fund transfers and program control.[77]

The most optimum strategy for manned space exploration is International Cooperation (see Figure 3). The cost to develop, deploy, and operate manned systems is extremely high, with very long schedules, requiring some method of cost sharing to be politically feasible. The primary benefits of space exploration are focused on the scientific community with potential cross over to the public sector, and have little national security interest. Finally, commercial providers of human spaceflight equipment are small in number.

Navigation

Satellite navigation began as a military specific capability to support precision munitions and tactical maneuver.[78] GPS continues to provide military commanders the ability to strike accurately worldwide, and is a mainstay in the public realm. Recently, China, Russia, and the ESA have begun the development and fielding of upgraded satellite navigation capabilities to provide an alternative capability separate from the US system.

As the prevalence of satellite navigation spread from military to civilian applications, a desire to migrate to a commercial solution was touted as the answer to high costs, and a dependency on US military satellites that could potentially be denied.[79] ESA attempts to create this environment have stalled, however. The plan to leverage commercial industry to build and operate Galileo collapsed when the risk to the private sector was deemed too high, and the European governments forced the dissolution of the developing consortium.[80]

Commercial innovation for satellite navigation is more evident in the receiver and ground processing elements. GPS receiver development has been reduced from 44 months to 5 months; computer upgrades occur every 18 months.[81] This high rate of replacement results in highly reliable, state-of-the-art equipment that is typically better than the military equivalent.[82]

The most optimum strategy to acquire satellite navigation systems is a Government Funded approach, with Industry Partnerships and International Cooperation considerations (see Figure 3). The cost to develop the system is high, and has little commercial appeal. Since the primary function of GPS is military focused, the needs of coalition partners need to be included, and industry can provide better downstream products more rapidly than the government.

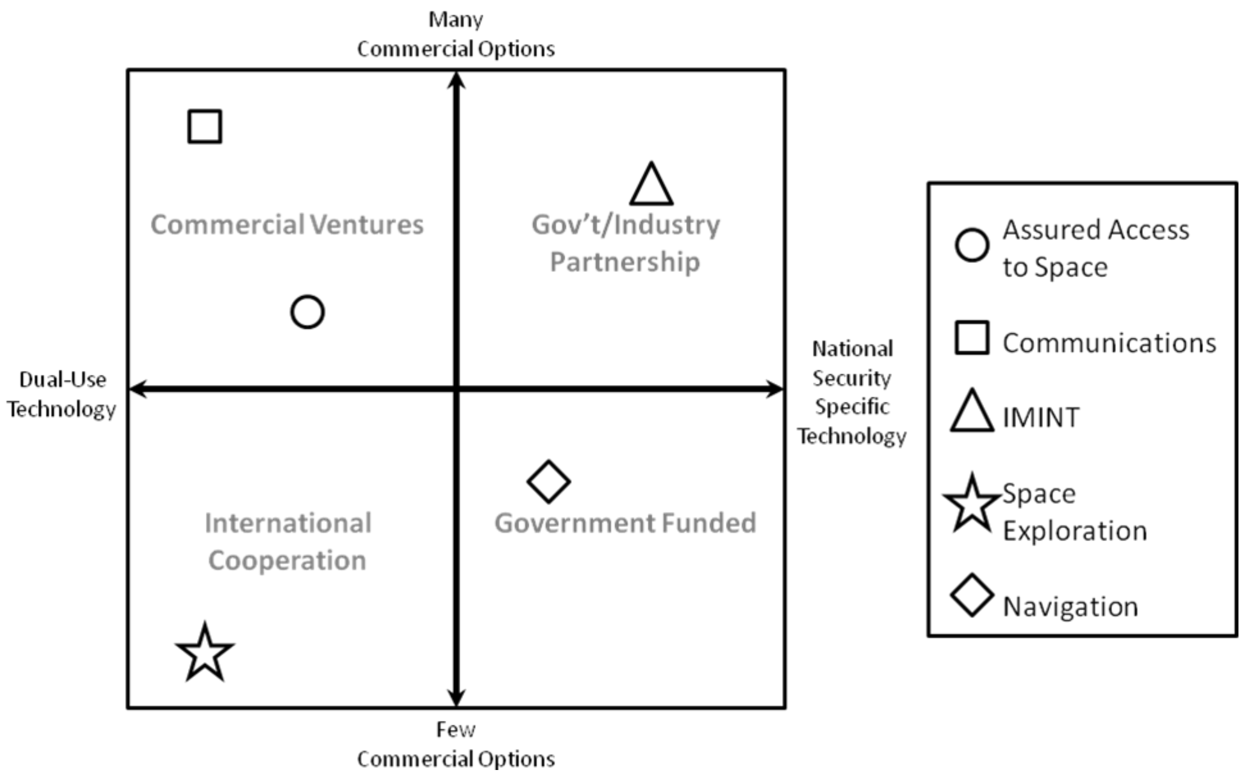

Figure 3. Optimum space strategy by capability

US Investment Strategy Comparison

The US investment strategy for any given capability typically does not align with the optimum. Whether due to a reluctance to change, bureaucratic limitations, or some other reason, this misalignment helps drive the massive expenditure disparity between the US and foreign competitors. The current US investment strategies must be understood in order to adequately provide recommendations to space policy.

United States – Assured Access to Space

The US has primarily used the strategy of Government/Industry Partnership in the development of space launch capabilities (see Figure 4). In 2006, Lockheed Martin and Boeing were authorized to create a joint venture, ULA, to serve as the primary launch provider for the US government.[83] The US also accommodates a commercial sector consisting of SpaceX, ILS, and SeaLaunch who offer viable launch solutions. However, ILS and SeaLaunch use boosters developed by foreign counties making both companies ineligible for US government launches.[84]

The consolidation of major launch providers following the Cold War was expected, but the lack of a robust, indigenous space transportation industry is considered by some critics to be a “national disgrace.”[85] The reliance on ULA as the predominant supplier of assured access to space is problematic. A fleet wide problem in 2008 resulted in only two launches during the year, and created a three year backlog posing scheduling conflicts throughout the manifest.[86] The US reluctance to use foreign developed launch vehicles creates a disadvantage compared to European and Russian counterparts who are more than willing to use one another’s assets when deemed appropriate. The multiple choices considered by the ESA and Russia encourage innovative solutions, competition, and a more robust launch capability.

The Partnership approach has provided some benefit. ULA recently completed the design for an adapter similar to the one on the Ariane 5 booster, permitting multiple, interchangeable payloads with an end goal of reducing government costs through increased launch opportunities.[87] The consolidation of launch providers also constrained the potential need for the government to support multiple companies to maintain a viable industrial base.[88] The evidence of a growing commercial sector partially invalidates this benefit, since ULA would have to be more proactive in the development of innovative designs if driven by competition.

The focus on a single provider for the majority of government launches limits the capacity for innovation and cost reduction, while simultaneously increasing the schedule risk and susceptibility to single points of failure. The failure to take advantage of commercial options has resulted in a declining US share of the global launch market due to restricted revenue growth.[89]

United States – Communications

The US has taken the first steps toward fully leveraging commercial solutions to provide satellite communication (SATCOM) capabilities, but still relies on Government/Industry Partnerships to fulfill the mission in some areas. The US government, the Department of Defense in particular, is hobbled by short term budget cycles and commerce regulations that do not allow the full range of commercial sector benefits.

"For the last several years, the Defense department has relied on commercial service for some 80 percent of its global demand for satellite connectivity."[90] However, the US continues to invest in expensive, military focused solutions that fulfill only partial requirements. The use of commercial options is further hampered by a lack of foresight in estimating yearly bandwidth requirements, and a reluctance on the part of the military services to work together to consolidate demand. Instead, each service purchases capacity from the high-priced spot market on an ad hoc basis. Furthermore, only the US Navy has the wherewithal to budget annually for commercial satellite communications; the remaining services rely on supplemental war funding to make up the difference.[91] This approach leaves industry unable to anticipate required bandwidth needs, and unable to design future systems to support national security requirements. The US is constrained by a myopic budgetary process, and limited desire to seek alternative methods for SATCOM capability.

The US is further hindered by the International Traffic in Arms Regulations (ITAR), a series of State Department rules concerning the export of sensitive technologies which limit the ability of US firms to compete in the international market.[92] As of July 2009, EchoStar Corp. was the only US Company listed in the top 25 of the global SATCOM market, and has revenues less than 2 percent of the world leader, Intelsat.[93] Without a viable market, commercial innovation and capacity suffers.

The US cannot meet the nation's SATCOM needs without commercial support, and the country's own limitations and regulations have placed the US at a severe disadvantage. The results are higher costs and a stymied indigenous capability unable to efficiently respond to government demand, or compete in the international market.

United States – Imagery Intelligence

The US continues to rely heavily on Government Funded systems to meet the vast requirements for imagery intelligence. Much like the SATCOM industry, ITAR restrictions constrain the commercial viability of US IMINT systems. Additionally, available commercial options are seen as merely gap fillers or supplemental assets, not as potential solutions.

The restricted ability for US companies to compete in the international imagery market has endangered national security, and weakened the US industrial base.[94] The National Geospatial-Intelligence Agency (NGA) is making progress toward awarding several contracts for radar images, but the primary data sources are international. "No U.S. companies currently operate commercial radar imagery satellites due in part to strict U.S. regulation of the technology...the nation lacks a domestic, second-tier source of commercial SAR data."[95] The end result is a dependency on foreign data to supplement national systems, while undercutting the ability for native companies to develop sophisticated collection assets.

Even when commercial options are obtainable, the US does not adequately leverage this availability. Current efforts within the National Reconnaissance Office (NRO) showcase a highly classified, $25 billion, telescope and radar system that shall become the backbone of the US IMINT fleet.[96] This is despite the fact that two commercial-class satellites are being purchased to fill a gap left by the NRO's cancelled Future Imagery Architecture program deemed not executable due to high costs and technical complexity.[97] If commercial assets are considered viable candidates as gap filler capabilities, these assets should also be under consideration as the primary means of providing IMINT products.

The inhibited local commercial market forces the US to look for government funded solutions to meet national security needs. The existence of many international companies capable of offering high-resolution images demonstrates a viable commercial market offering comparable solutions at a fraction of the cost of government procurements.

United States – Space Exploration

The planned retirement of the Space Shuttle, and the cancellation of the Constellation program effectively eliminates any indigenous US manned space capability. The US has historically relied on Government Funded solutions that are extremely costly, and under-supported by the public. The recent shift to possible commercial ventures reveals a wider selection of options, but fails to capitalize on the vast potential of international cooperation.

The Constellation program, before being cancelled, was estimated to cost at least $230 billion, and would not return astronauts to the moon until 2020.[98] At that cost, the US could fly at least 4,509 astronauts for the next 20 years aboard the proven Russian Soyuz capsule.[99] Meanwhile, the Chinese continue to develop a manned capability which draws heavily from Russian designs.[100] The willingness to leverage international solutions helps explain China's achievements with a space budget 95 percent smaller than the US. The ESA is also exploring possible manned solutions with Russia for cost-sharing reasons. The widespread desire to partner with other countries provides the perfect opportunity for the US to engage in the international development for space exploration.

In 2009, NASA set aside $150 million to foster commercial development to return astronauts to the ISS, but this effort ignores the availability of already developed, international solutions.[101] NASA is currently attempting the same strategy for ISS cargo vessels under the Commercial Orbital Transportation Services program. However, the Russian Progress vehicle and ESA's ATV already fulfill that critical role. US resources are better spent providing a solution to an unanswered problem rather than creating a tertiary backup.

An international conglomeration built the International Space Station, and leveraging international solutions is the only means of overcoming the sheer cost and schedule required to develop a new manned capability. The US attempt to subsidize the commercial sector to create a redundant, non-marketable solution simply disenfranchises an already skeptical public.

United States – Navigation

The US development of GPS was initially an American-led, Government Funded effort to help eliminate redundant positioning capabilities for a wide variety of military purposes.[102] Since the initial deployment of GPS, the US has welcomed participation from allied partners and the commercial sector to refine and advance the technology. This strategy has placed the US in the enviable position of having the ability to respond to civilian and military requirements with a robust capability that is significantly beyond potential competitors.

Future iterations will further solidify GPS's presence in the international realm. GPS III's signal strength is increased a factor of ten to reach more customers, and is designed to be compatible with the ESA Galileo system.[103] GPS III also continues to surpass China's Beidou satellites with a five-fold increase in accuracy and a global, rather than regional, presence.[104] The integration of GPS units into many combat assets, and the on-going development of commercial receivers and applications indicate the system provides a significant benefit to fielded forces.

The military specific requirements, lack of a commercial market for the satellite system, and willingness to incorporate international and industry recommendations aligns perfectly with the optimum solution for this capability. The US must maintain this approach to ensure GPS remains ahead of foreign adversaries in this area.

Analysis Summary

As Figure 4 demonstrates, except in the area of space navigation, the US is misaligned between the optimum investment strategy for each capability and the US preferred approach.

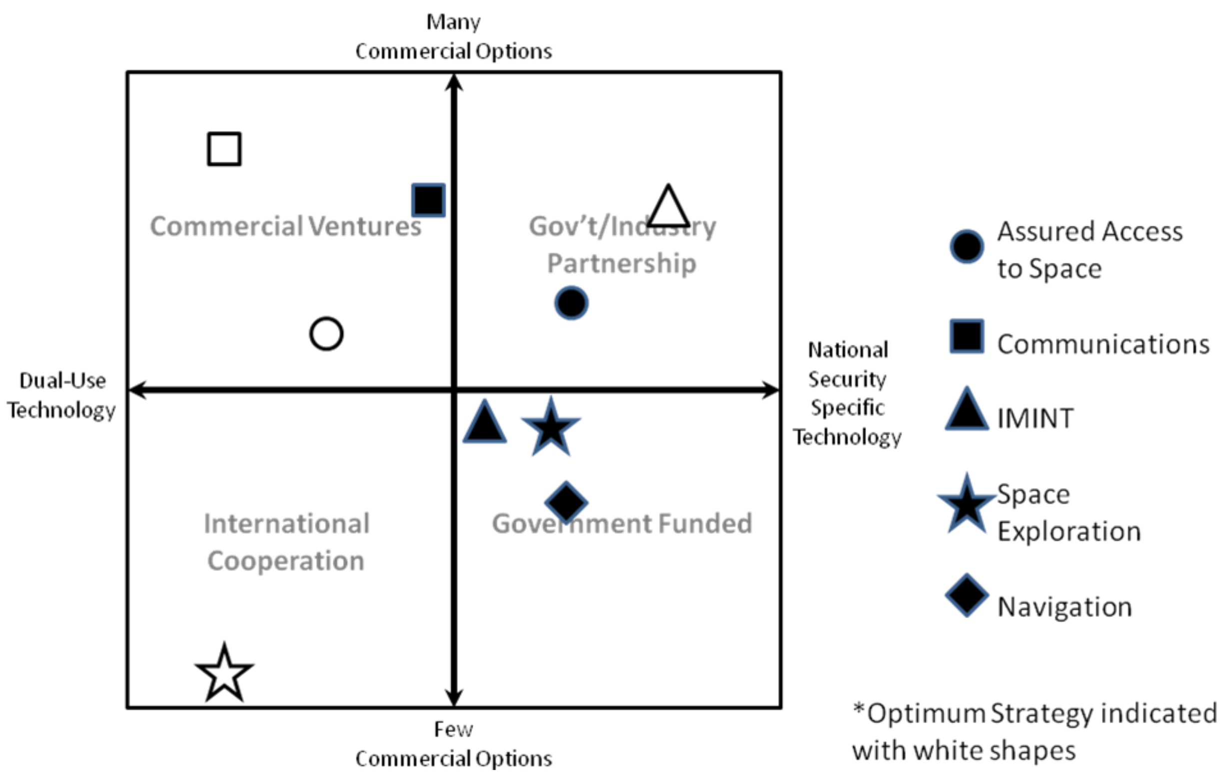

Figure 4. US versus Optimum investment strategy by space capability

The US prefers to leverage the Government Funded approach with very limited forays into the commercial market or international cooperation. The US must modify the fundamental approach to space technology development to regain dominance of the space arena.

CONCLUSIONS/RECOMMENDATIONS

Conclusions

The disparity between the optimal and US preferred investment strategies for each space capability supports the notion that the current US space development model is a "'Cold War relic'...[that] fosters deployment of systems too few in number, laden with a watered-down or cumbersome set of capabilities, and saddled with long shelf-life requirements that do not keep pace with technological advances."[105] The US relies too heavily on direct government involvement that concentrates the effort into a consolidated pool of producers who may one day be unable to provide the needed systems.[106] The fear of technology proliferation has driven the creation of overly restrictive regulations designed to contain the spread of technology, but which has only spurred the international development of banned systems, while restraining US industry growth. The combined result is a set of programs that are over budget, behind schedule, excessively controlled, and lacking the innovative legacy of US technological development, that erodes public support and alienates international partnerships for space.

To overcome these shortcomings, the US must begin to look beyond government solutions and toward commercial enterprises to fulfill space related requirements. The mass proliferation of space based commercial assets offers capabilities in the form of COTS products or services at a fraction of the cost of a traditional government procurement. Furthermore, commercial assets provide a level of innovation and tailoring that benefit the US government both militarily and economically.

Similarly, the US must avoid taking a prideful stance, and foster international cooperation to help shoulder the burden of exorbitant costs for mutually advantageous gain, especially for projects that are scientifically inclined, or have little relation to national security. The benefit is two-fold. First, the cost to develop wholly new space systems is extremely high, to the point where no single country can provide the necessary resources alone.[107] Second, the managed coordination of cooperative work reduces the chance of unintentional technology transfer, while simultaneously combining resources during joint work.[108]

In addition to modifying the investment strategies, the US must work toward purging erroneous government restrictions on industry, especially ITAR. This overarching set of laws continues to target technology that has already proliferated, and constrains the ability of US companies to compete in the international market. The transition of ITAR from the Department of Commerce to the Department of State further complicates matters due to the inexperience of the State Department regarding international markets.[109]

Finally, the US government needs to embark on a public relations campaign to kindle the emotion and desire of the public sector. Weak demand and inspiration manifests in two key ways. The public needs assurance that the high cost of space systems is returned in tangible benefits for the betterment of society. Without this assurance, projects appear wasteful, and politically volatile. Also, the technologically inclined requirements for building space systems require a like minded population to replace an aging developer workforce.[110]

The US must shift investment strategies, eliminate ineffective barriers to industry, and re-instill public exuberance for the space program. "Doing so will place this country on an energetic, inspiring and sustainable path in space – one that contributes to our technological productivity, economic growth and global stature in the 21st century."[111]

Recommended Changes to Current US Investment Policy

Space Capability Investment Strategy Modifications

Except in the area of satellite navigation, where the US drastically outpaces the closest competitor, the US has the opportunity to make significant changes in the nation's investment strategies. The first step to improving and solidifying the US position among the world space leaders is to greatly increase the consideration of commercial assets, especially in the areas of assured access to space, satellite communications, and imagery intelligence. More specifically, the US should expand the use of commercial services, vice actual products, for space launch and SATCOM, and partner with industry to provide IMINT assets that most closely meet national security requirements. Finally, if the US continues to pursue manned space exploration, future projects must dwell in the international arena, and not be conducted by NASA alone.

Space launch should no longer be under the sole purview of US government developed systems. The multitude of internal and external assets demonstrates the availability of a commercial market, complete with the trappings associated with the increased competition. The US government's continued subsidizing of the launch market to ULA places potential competitors at a severe disadvantage for little actual benefit. This method also provides little incentive for ULA to develop innovative solutions to lower cost.

Instead, the US must look to all available indigenous providers to support national security related launches. Additionally, the support should be provided in the form of a launch service rather than a purchased booster. This would require commercial industry to compete through lower costs and specialized benefits. The open availability of lucrative government backed contracts widens the possibility of less traditional companies gaining a foothold to compete in the US and international markets, further enticing new means of expanding market share. The government must accept potential higher risk in the near term as younger companies build up the track record of the legacy systems, but the long term horizon of this approach is more advantageous. The US must also forego the American-made only mentality concerning available launch assets.

Satellite communications is another area where commercial providers can produce a much more streamlined product than currently provided by the government. The combined demand of the US Navy, Air Force, Army, and Marine Corps during peacetime represents a substantial consumer bloc who can reliably measure needed SATCOM requirements on a yearly basis. This purchasing power, executed through a central commercial service, can be harnessed to influence commercial development of communication satellites. Also, pre-purchased bandwidth is more likely cheaper than purchasing on an ad hoc basis since multi-year profiles allow industry to tailor satellite fleets to meet expected demand.[112] Additionally, if commercial providers understood the military requirements for secure communication links, industry could develop systems with the required capabilities, thus removing the government onus of developing and maintaining a communication system easily supplanted by a commercial option.

The US strategy for developing IMINT satellites on an individual basis, with competitions focusing on the entire spacecraft wastes valuable resources in the re-creation of an already developed product. The first change in IMINT strategy is to look for commercial options that fulfill a majority of the requirements for IMINT, either in the form of COTS products or through an imagery service. The US National Imagery Mapping Agency, now NGA, “buy to deny” policy in 2002 indicates the commercial market can support this approach for the required end product.[113] Purchasing already developed products eliminates the need to invest large sums of money in non-recurring engineering costs, and decreases risk by launching a proven solution.

The second change is related to national security requirements. Instead of purchasing wholly new systems to replace or upgrade existing assets, the US government should focus resources on the specific areas of difference, such as the sensor, and leverage commercial standards for the remaining portion. Boeing developed a modular satellite bus capable of supporting a wide range of military and commercial payloads designed with plug-and-play interfaces for easy modification.[114] Using this approach, the US can purchase the 80 percent solution commercially, and tailor the system with the required sensors, without having to purchase specialized power supplies, communication equipment, electronics buses, or ground stations. Common baselines also decrease the cost of maintaining satellites through code reuse and interchangeable hardware.

The final strategic modification is for the US to leverage international partnerships in the pursuit of space exploration. The US may have been the leader in space exploration through the 1990's, but the retirement of the space shuttle, and the new development in China, Russia, and the ESA point to a more level playing field. The US must combine the country's experience with the drive of the rest of the world to create a robust system that benefits all mankind.

The international approach offers much more than simple cost sharing. Schedules for scientific endeavors are not driven by operational need, negating the timeline impacts of international cooperation. More importantly, cooperation binds nations to a common goal, uniting the participants economically and politically, and allowing the values of each nation to shape foreign policy. There is no greater way for the US to influence Russian and Chinese development, short of military force, than demonstrating a willingness to work alongside one another for the common good. "Reaffirming America's heritage of exploration engages the best and brightest of the nation to tackle energy, health and environmental concerns while seeking out new horizons beyond our home planet."[115]

International Traffic of Arms Regulations

The US development of superior technology throughout the Cold War provided the impetus for maintaining specific advantages through policy and the instantiation of ITAR. Initially regulated by the Department of Commerce, the transfer of responsibility to the State Department ensnared many space related capabilities in a myriad of licenses, export controls, and government regulations. The US must eliminate onerous barriers to industry that do nothing to secure the nation, or regain the top position among the world space powers.

The easiest and most effective manner to alleviate this issue is to shorten the number and types of technology included in ITAR. The list continues to include technologies that have proliferated to the very countries the restrictions were designed to inhibit. A review of the list in order to remove those technologies which are no longer sensitive would continue to protect national security while opening international markets to US companies. A less effective approach is to modify the current regulations pertaining to licensing and oversight. A single interaction oftentimes requires multiple licenses and overly strict restrictions that introduce unnecessary delays and costs, presenting hurdles US companies are unwilling to address.[116] The end result is a loss of market share, and a smaller indigenous industrial base.

The Obama Administration asserted that ITAR reform was at the top of the political agenda, but little headway has been made thus far. The lack of a home-grown space radar capability and a dependency on international solutions for optical IMINT and SATCOM exemplify the continuing problem. ITAR issues must be resolved as soon as possible either through an overhaul of the technology list, or by streamlining the process.

Public Perception

The final recommendation delves into the esoteric realm of public support for the space program. Although not directly related to the investment strategies of actual capabilities, public perception continues to play a significant role in defining US policy. "No policy or strategy for assuring U.S. uses of space for national security and economic purposes can be successful without public support."[117] The government must address the waning public support for space now, in order to ensure the program's survival in the future.

President Kennedy framed the first space race as a matter of national security and American prestige. The strategic vision galvanized the public, who viewed the astronauts of the time as heroes or movie stars, and overlooked the extravagant cost. This glut of popularity has diminished significantly amid an American public convinced the US has already won the space race, and a media more interested in mishaps and scandal than accomplishments.

The recommended policy change is to once again engage the public in the importance of the space program. The success of GPS in the civilian world is attributed to the media's coverage of the system during the Gulf War.[118] This same technique must be used for current and future development. The public needs to understand the purpose of the space program, provided in a clearly articulated strategy that aligns with society's values. Future systems must involve dual-use capabilities that provide tangible benefits to the population as a whole.

The makings of a renaissance are at hand. Space is no longer solely in the hands of two superpowers, but accessible to four major parties, with several more on the way. The well advertised development of space systems that address the issues of today, such as climate change, alternative energy sources, or advanced computer technology, will reignite a disengaged public, and ensure the continued use of space for peaceful purposes.

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